Peat swamp forest birds of the Tuanan research station, Central Kalimantan, Indonesia, with notes on habitat specialists

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The avifauna of tropical peat swamp forest has not been well documented, even though it is an extensive habitat in parts of South-East Asia. We conducted surveys using various methods at the Tuanan research station and surrounding areas in Central Kalimantan, Indonesian Borneo. These observations resulted in a list of 138 bird species and numerous noteworthy records. Although more depauperate than lowland rainforest on mineral soils, peat swamp forest is an important habitat for many threatened and Near Threatened bird species, especially habitat specialists such as Hook-billed Bulbul *Setornis criniger* and Grey-breasted Babbler *Malacopteron albogulare*. We also recorded in selectively logged peat swamp several high-profile, globally threatened species such as Crestless Fireback *Lophura erythrophthalma*, Storm's Stork, *Ciconia stormi*, Great Slaty Woodpecker *Mulleripicus pulverulentus*, Black Hornbill *Anthracoceros malayanus* and Wrinkled Hornbill *Aceros corrugatus*. In view of its importance to certain species, peat swamp forest should be afforded more protection, especially in light of the recent rapid loss of this habitat to land conversion and forest fires.

INTRODUCTION

Borneo is the third largest tropical island in the world and particularly rich in biodiversity, with 630 recorded bird species (Mann 2008). Geopolitically, the island is divided into Brunei Darussalam, the Malaysian states of Sabah and Sarawak, and the four Kalimantan provinces of Indonesia. Most of the ornithological work on Borneo has been conducted in the northern part of the island, and Kalimantan remains poorly studied, with only a few avifaunal lists published specifically for this region (e.g. Holmes & Burton 1987, Holmes 1997). In Central Kalimantan, the second largest province of Indonesian Borneo with a land area of 154,564 km^2, bird surveys have largely concentrated in a few well-known areas such as Tanjung Puting National Park and Barito Ulu (Bohap & Galidikas 1987, Nash & Nash 1988, Dutson *et al.* 1991, Wilkinson *et al.* 1991). The extensive tropical swamp forests dominating the southern lowland plains of Central Kalimantan have largely been ignored and unexplored, even though these habitats constitute one of the seven biogeographic zones of Borneo and have an important influence on species distribution (MacKinnon *et al.* 1996).

Tropical peat swamp forest (PSF) is a unique wetland ecosystem that develops in areas where waterlogging prevents the complete decomposition of plant debris, which over time accumulates as peat soils (Anderson 1983). PSF occurs throughout the tropics but reaches its greatest extent and depth in South-East Asia, especially in the lowlands of Sumatra and Kalimantan (Rieley *et al.* 1996). PSFs are characterised by periodic flooding, nutrient limitation and high acidity due to the leaching of organic compounds. PSF trees are adapted to tolerate nutrient deficiency, unstable substrate and fluctuating water levels, and in this respect exhibit structural features such as stilt roots and pneumatophores. The overall primary productivity and biodiversity levels in this nutrient-deficient forest type are lower than in lowland forest on mineral soils (Bruenig & Droste 1995).

The neglect of PSF by biologists might result either from its relatively depauperate flora and fauna or from the difficult access and working conditions brought about by the boggy soils and dense understorey vegetation, which severely hamper movement and visibility. However, recent research indicates that PSF may harbour a considerable proportion of the South-East Asian fauna (Posa *et al.* 2011). Thus, there is an urgent need for more information on the flora and fauna of this unique ecosystem, as its destruction has accelerated in recent years. Nearly half of the PSF in Peninsular Malaysia, Borneo and Sumatra has been lost since 1990 (Miettinen & Liew 2010). Many areas have already been converted into oil palm and paper pulp plantations and much of what remains under forest cover has been selectively logged (Miettinen & Liew 2010). Such disturbance renders PSF extremely prone to forest fires, since peat itself is combustible when dry (Page *et al.* 2009). Fire is now one of the major drivers of PSF loss and conversion to degraded land.

In this paper, we present the first avifaunal list for the Tuanan research station in the Mawas Conservation Area and surrounding areas based on field observations, mistnetting and camera trapping conducted in Central Kalimantan from 2009 and 2010.

STUDY AREA AND METHODS

The Mawas Conservation Area comprises a 3,000 km^2 area managed by the Borneo Orangutan Survival Foundation located east of the Kapuas river, about 55 km from Palangkaraya, the capital of Central Kalimantan (Figure 1). Here, the Tuanan research station (2°09′06″S 114°26′26″E) was established in 2003 for long-term Orangutan behavioural studies. It comprises a 9.45 km^2 grid-based trail system situated on peat of varying thickness up to 2 m. The forest was subjected to selective commercial logging in the early 1990s, followed by illegal logging (van Schaik *et al.* 2005). However, there has been no systematic logging since 2002 (Vogel *et al.* 2009). Despite this disturbance, the forest supports a relatively high density of Bornean Orangutans *Pongo pygmaeus wurmbii*, Bornean Agile Gibbons *Hylobates agilis albibaris* and other globally threatened mammals (van Schaik & Brockman 2005, pers. obs.). Central Kalimantan has a humid tropical climate, with very little variability in temperature. The wet season normally occurs during the north-west monsoon in November to April; the climate is drier during June to August. There is some climatic variation associated with the El Niño Southern Oscillation cycle, which affects the duration and severity of the seasons. During strong El Niño events, southern Kalimantan can experience prolonged drought conditions (Page *et al.* 2009). The mean average annual rainfall measured from 2004 to 2007 at the Tuanan research station was 2,678 mm, with an average monthly rainfall of 223 mm (Wartmann 2008). Outside of the Mawas Conservation Area, the PSF has been heavily disturbed by humans. Drainage canals dug in the early 1990s for the Indonesian government's Mega-Rice Project have disrupted the natural hydrology of the area, making it extremely prone to fire (Page *et al.* 2009). As a result, large areas have been subjected to one or more fires and are now dominated by ferns and other low-growing plants.

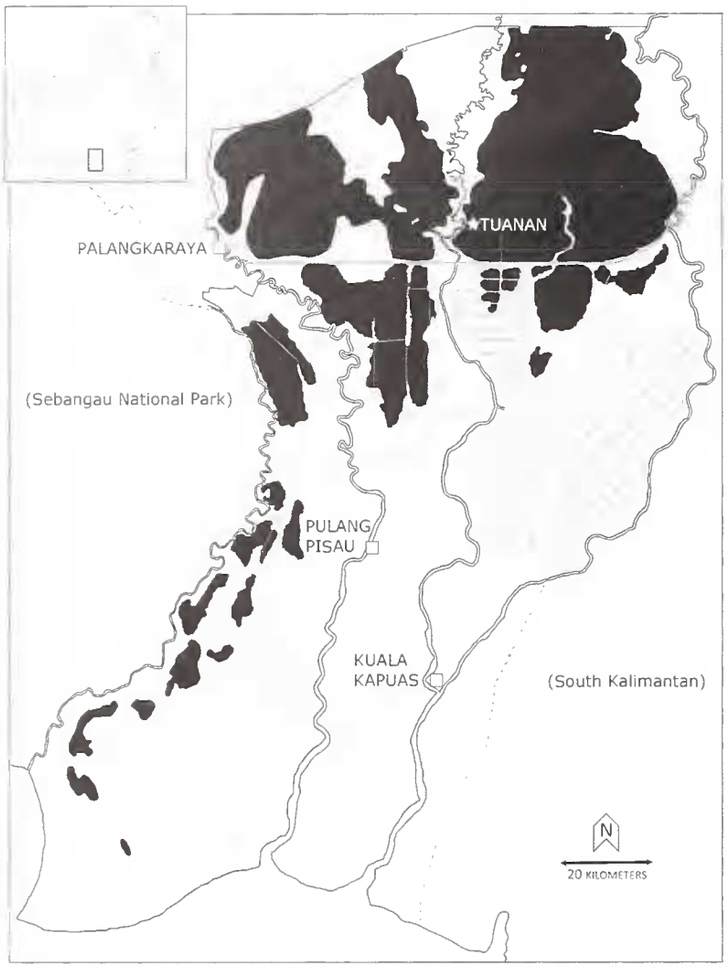

Figure 1. Map of the ex-Mega-Rice Project area with remaining peat swamp forest cover (in black). Approximate location of the Tuanan research station indicated. Straight solid grey lines are canals that were dug for drainage.

Bird observations were made in the intact PSF around the Tuanan research station as well as in surrounding degraded areas using a variety of methods. DM made *ad libitum* observations from November to December 2009, while MRCP conducted standard 10 minute, 25 m radius point-count surveys from August 2009 to July 2010 (Posa 2011). In addition, MRCP also used mistnets and camera traps to survey Tuanan for a total of 2,535 net hours and 3,924 trap nights respectively (details of methodology in Posa 2011). We included in our list only species that were confirmed by visual sightings or distinctive calls, mistnetting and camera trapping. With the exception of Bornean Ground Cuckoo *Carpococcyx radiatus* (following Collar & Long 1996), nomenclature follows the 2009 checklist of the Oriental Bird Club (sequence of Dickinson 2003) available online at http://orientalbirdimages.org/new-obc-checklist.html.

RESULTS

We recorded a total of 138 bird species from all survey methods in the intact and degraded PSF habitats in and around the Mawas Conservation Area (Appendix). Four of these were migratory species, and two were most likely introduced recently to Borneo. Thus, 132 resident birds were found in the PSF. Twenty-six species were observed only along canals or rivers and in the non-forested regrowth vegetation in areas that had previously been burned. The rest of the species were observed in logged PSF and remnant forest fragments. Several species of particular interest were observed, including seven globally threatened, 31 Near Threatened species as well as two PSF specialists (Hook-billed Bulbul *Setornis criniger* and Grey-breasted Babbler *Malacopteron albogulare*) and three Bornean endemics (Bornean Ground Cuckoo, Bornean Bristlehead *Pityriasis gymnocephala* and Dusky Munia *Lonchura fuscans*).

We captured a total of 293 birds from 28 species in mistnets (see Appendix), with recaptures (21 individuals) comprising 7.2%. Two species that were recorded only by mistnetting were Blue-eared Kingfisher *Alcedo meninting* and Oriental Cuckoo *Cuculus saturatus*. Camera traps took 45 photographs of birds from ten species, of which we were unable to identify three. Three species were detected only through photography, namely Black Partridge *Melanoperdix niger*, Crestless Fireback *Lophura erythrophthalma* and Bornean Ground Cuckoo.

Significant records

Species accounts are given for threatened species, endemics and habitat specialists and a few other notable records. We give the species conservation status (Endangered, Vulnerable, Near Threatened, Least Concern) based on the 2010 Red List by the International Union for Conservation of Nature (IUCN 2010).

Black Partridge *Melanoperdix niger*

Vulnerable. A lone female was photographed in July 2010 in the early morning. An uncommon and local resident on Borneo, this species is poorly known, as it is shy and secretive. It has been recorded from swamp forest in Gunung Palung National Park (Laman *et al.* 1996).

Crestless Fireback *Lophura erythrophthalma*

Vulnerable. Only detected by camera traps in intact forest, but the commonest bird species recorded using this method (29 of 45 photographs of birds). Pictures of individuals or pairs were taken between dawn and dusk, but the majority of photos was taken before 08h00. Other researchers reported occasional encounters on man-made transects, but in general this species is very elusive.

Storm's Stork *Ciconia stormi*

Endangered. Recorded three times by camera traps and two seen flying over the research station in the early morning in June 2010. This species has also been reported from other swamp forests, including peat swamp (Laman *et al.* 1996, Danielsen *et al.* 1997, Page *et al.* 1997). It is considered very rare throughout its range, but our record and the recent one in Thailand, where it was thought to be extinct (Cutter *et al.* 2007), indicates that camera trapping is a very useful method in detecting this species's presence in forested areas.

Lesser Adjutant *Leptoptilos javanicus*

Vulnerable. A few to a dozen individuals were spotted at various times in drained and deforested areas while travelling on canals in May–July 2010.

Wallace's Hawk Eagle *Spizaetus nanus*

Vulnerable. An adult was observed perched in the PSF interior in December 2009.

Cinnamon-headed Green Pigeon *Treron fulvicollis*

Near Threatened. Individuals and a group of three were seen feeding in fruiting trees lining canals in the deforested area in September 2009. This species was not recorded in intact forest, but was possibly overlooked. It has also been recorded from PSF in Sebangau (Page *et al.* 1997) and was reportedly the most abundant green pigeon in the wooded areas of the Barito region and southern Kalimantan by Holmes & Burton (1987).

Long-tailed Parakeet *Psittacula longicauda*

Near Threatened. One bird was observed in PSF in December and groups of more than a dozen birds were seen on dead remnant trees in degraded areas in August to November 2009.

Chestnut-bellied Malkoha *Phaenicophaeus sumatranus*
Near Threatened. Surprisingly, a commonly encountered bird in the PSF interior habitat, travelling in singles, pairs or groups of three birds. Reported as uncommon throughout Bornean lowland and hill dipterocarp forests (Mann 2008).

Bornean Ground Cuckoo *Carpococcyx radiatus*
Near Threatened. Endemic. One individual was photographed following a Sun Bear *Helarctos malayanus* in December 2010. Described as a rare resident of lowland forests (Mann 2008). It has been recorded in a few other places in Central Kalimantan in alluvial and swamp habitats (Long & Collar 2002, Fredriksson & Nijman 2004).

Black Hornbill *Anthracoceros malayanus*
Near Threatened. Small groups of up to eight individuals were uncommonly encountered in intact forest.

Wrinkled Hornbill *Aceros corrugatus*
Near Threatened. One adult male was observed in PSF in November 2009.

Red-crowned Barbet *Megalaima rafflesii*
Near Threatened. The commonest barbet in PSF and disturbed forest around Tuanan with up to eight individuals recorded in a day.

Great Slaty Woodpecker *Mulleripicus pulverulentus*
Vulnerable. Noisy conspicuous groups were uncommonly encountered in intact forest and also observed in forest fragments in the degraded area. This species has also been reported from PSF in West Kalimantan (Laman *et al.* 1996).

Bornean Bristlehead *Pityriasis gymnocephala*
Near Threatened. Bornean endemic. Considered to be rare and uncommon on the island (Mann 2008). Individuals and small groups of up to five birds were uncommonly encountered in intact PSF and forest fragments in the degraded area. This species has been reported from PSF in Sarawak (Laman *et al.* 2006) and the 'swamp' forests of Tanjung Puting (Nash & Nash 1988). Smythies (1981) suggested that it may prefer PSF, but Witt & Sheldon (1994) refuted this.

Hook-billed Bulbul *Setornis criniger*
Vulnerable. PSF habitat specialist. Fairly common in intact forest, often travelling in small groups. Their call has been described as a rattling series of notes (3.4 kHz, 11 notes) or a soft *crrrk* (Myers 2009) or harsh alarm *cuurrk* (MacKinnon & Phillipps 2008). These bulbuls are quite easy to detect in the PSF understorey because of these calls, which we were able to record (Figure 2; www.xeno-canto.org catalogue number XC74801). We also caught six individuals in mistnets. This species has been observed in other nutrient-poor forests in Borneo and was described as a local lowland resident (Mann 2008). In Central Kalimantan, it has been recorded in swamp forest in Sebangau (Page *et al.* 1997) and Tanjung Puting, as well as frequently encountered in kerangas at Barito Ulu (Dutson *et al.* 1991). It has been suggested that *Setornis criniger* is intolerant of habitat degradation (Dutson *et al.* 1991), but our observations indicate that it can persist in large blocks of selectively logged PSF. However, the rapid loss of this habitat will continue to threaten this species.

Grey-breasted Babbler *Malacopteron albogularis*
Near Threatened. PSF habitat specialist. This species is rare except in poor soil habitats such as PSF, kerangas and ultrabasic forests (Sheldon *et al.* 2001). It is often overlooked because of its skulking habits, absence from mixed-species flocks and infrequent vocalisations. We observed it only on three occasions in the understorey. However, it was the fourth most commonly mistnetted species (19 out of 272 individuals), supporting the suggestion by some authors that this method can reveal its presence (Sheldon 1987, Dutson *et al.* 1991). Thus it may be overlooked even in habitats where it is fairly common. Birds from Barito Ulu and Tanjung Puting are described as having white lores, while those from north Borneo have yellow lores (Dutson *et al.* 1991, Sheldon *et al.* 2001), but see Collar (2011). The lores of the adult birds captured at Tuanan were white but consistently have a few rufous feathers on the edge near the forehead. We captured one juvenile with an inflated gape on 14 June 2010. It had similar coloration to the adult, except for a yellow lower mandible (grey in adult), brown iris (red in adult) and pink legs (grey in adult).

Crimson-breasted Flowerpecker *Prionochilus percussus*
Least Concern. Observed on four days in November–December 2009 and on three days in March–June 2010 with a maximum of four individuals. This species is supposed to be a rare lowland resident, especially in northern Borneo (Mann 2008), but identification issues may mask its true occurrence. No Yellow-rumped Flowerpeckers *P. xanthopygius* were observed in the Tuanan PSF, supporting the statement by Holmes & Burton (1987): '*xanthopygius* occurs with *percussus* in upper Barito Sep 1986 but not with it in southern lowlands of Kalimantan'.

Scarlet-breasted Flowerpecker *Prionochilus thoracicus*
Near Threatened. Single adult males were observed on two separate occasions in the canopy of the PSF interior. An uncommon and local bird on Borneo (Mann 2008). It seems to prefer poor soil habitats (Sheldon *et al.* 2001).

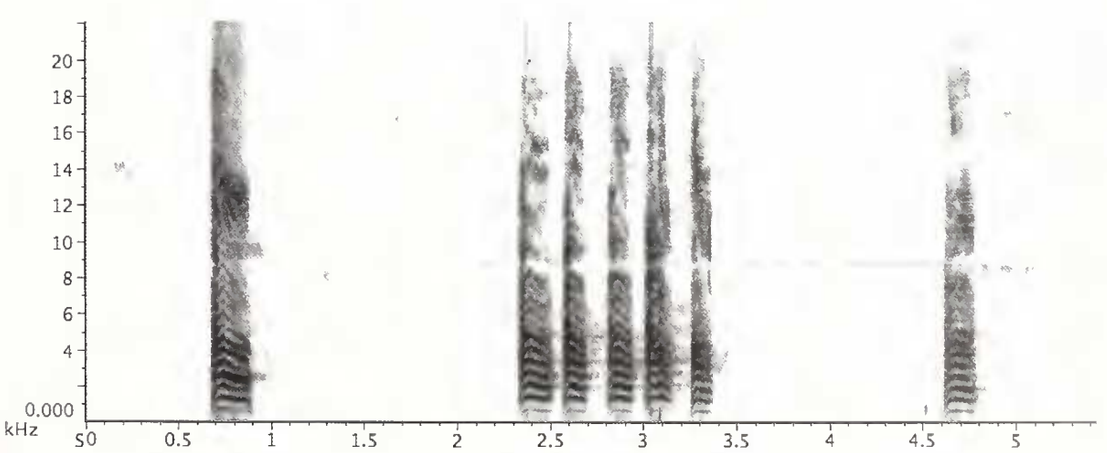

Figure 2. Sonagram of the *crrrk* or *cuurrk* call typical for Hook-billed Bulbul *Setornis criniger*.

Dusky Munia *Lonchura fuscans*
Least Concern. Bornean endemic. Not uncommon in disturbed forest, forest edge and forest regrowth areas around the Tuanan site.

DISCUSSION

While only one study (Gaither 1994) has made a direct comparison and shown that bird diversity in PSF is lower than in lowland rainforest on mineral soils, we reach the same conclusion from our survey in this nutrient-poor environment. We observed only 132 of Borneo's 398 resident bird species in PSF, including only three of at least 41 Bornean endemics, whereas other lowland sites around Borneo show higher species richness—even up to twice those numbers in eastern Sabah where forests are unusually rich (e.g. Lambert 1992, Johns 1996, Cleary *et al.* 2007, Edwards *et al.* 2011). Aside from fewer numbers of species and endemics, total abundance of observed birds is also very low. However, if we compare the bird species (102) found in the Tuanan PSF (excluding degraded and riverine areas) with other sites on Borneo containing PSF (Appendix), the numbers of species are roughly similar. Laman *et al.* (1996) reported 104 resident species from Gunung Palung National Park, which contains about 400 ha of swamp forest in a mosaic with lowland dipterocarp and upland forests. Tanjung Puting National Park, which is composed of 50% PSF in mosaic with freshwater swamp and heath forests, has 111 resident species reported in its 'swamp forest' by Nash & Nash (1988), although these authors surveyed peat basin margins and not true PSF. Our list shares 97 species (41%) with the lowland habitats of the Cabang Panti research site in Gunung Palung (61 reported from PSF and an additional 36 reported from lowland dipterocarp forest) and 123 species (56%) with Tanjung Puting, including 104 species reported from swamps by Nash & Nash (1988) with an additional 19 reported by Bohap & Galdikas (1987). Page *et al.* (1997) reported 150 species of birds observed over three years from various habitats, including both forest and riverine sedge swamp, at the Sungei Sebangau catchment in Central Kalimantan. However, because they did not provide a complete list of species, we cannot directly compare their results with ours.

Mistnetting has been conducted in PSF at only a few other sites on Borneo. Gaither (1994) captured 34 species in Gunung Palung but did not provide a complete species list. In Sarawak, sporadic mistnetting from 1996 to 1999 in a previously logged 20-ha patch of PSF at the UNIMAS Campus near Kuching revealed 68 resident species (Tuen & Darub 1999, Rahman & Tuen 2006). However, most of these (31) were represented by one or two captures only, including *M. albogulare*. They also failed to detect *S. criniger*, which suggests the site is heavily degraded and fragmented. In PSF at Loagan Bunut National Park, mistnetting during a short 10-day survey yielded 18 resident species, including *S. criniger* but not *M. albogulare*; observations produced an additional 12 species (Laman *et al.* 2006). In Sabah, six-days of mistnetting in primary PSF of the Klias Forest Reserve (Sheldon *et al.* 2004) yielded 28 species. While it is more difficult to set up mistnets in PSF than in dryland forests, this method is very effective and, thus, useful for studying understorey species, particularly in revealing the presence of *M. albogulare*. However, with the mistnetting bias towards understorey species and the low number of recorded species compared with point count sampling, researchers should be judicious in the use of mistnetting for rapid assessments of avian biodiversity in PSF (Remsen & Good 1996).

Camera trapping of birds has usually been incidental to surveys of terrestrial mammals, but it is starting to be explored as a viable method for sampling large ground-dwelling bird species (O'Brien & Kinnaird 2008). Although low numbers of birds were recorded with this method, it is a valuable method for detecting rare and elusive species such as *L. erythrophthalma* and *C. stormi* in addition to the other standardised procedures.

Kalimantan's PSF may represent a stronghold for *S. criniger* and *M. albogulare*, as large, albeit disturbed, tracts of this habitat still remain. These species are most likely to be declining in Peninsular Malaysia and Sumatra, where a greater percentage of PSF has been converted to plantations and other non-forest land uses (Miettinen & Liew 2010). Their current status needs to be assessed and monitored in light of the recent rapid loss of PSF habitats. More research is needed on the local distribution of bird species in PSF, and specific microhabitat requirements of these species in PSF needs to be elucidated. Despite low bird diversity in PSF, the occurrence of the PSF specialists *M. albogulare* and *S. criniger* together with other threatened and Near Threatened species underlines the urgent need for continued efforts in the Mawas Conservation Area to prevent further habitat loss and hunting.

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REFERENCES

Anderson, J. A. R. (1983) The tropical peat swamps of western Malesia. Pp.181–199 in A. J. P. Gore, ed. *Mires: swamp, bog, fen and moor: regional studies. Ecosystems of the World, Vol. 4B*. New York: Elsevier Scientific Pub. Co.

Bohap, J. & Galdikas, B. M. F. (1987) Birds of Tanjung Puting National Park, Kalimantan Tengah: a preliminary list. *Kukila* 3: 33–37.

Bruenig E. F. & Droste H. J. (1995) Structure, dynamics and management of rainforests on nutrient-deficient soils in Sarawak. Pp.41–53 in R. B. Primack & T. E. Lovejoy, eds. *Ecology, conservation and management of Southeast Asian rainforests*. New Haven: Yale University Press.

Cleary, D. F. R., Boyle, T. J. B., Setyawati, T., Anggraeni, C. D., van Loon, E. E. & Menken, S. B. J. (2007) Bird species traits associated with logged and unlogged forest in Borneo. *Ecol. Appl.* 17: 1184–1197.

Collar, N. J. (2011) Taxonomic notes on some Asian babblers (Timaliidae). *Forktail* 27: 100–102.

Collar, N. J. & Long, A. J. (1996) Taxonomy and names of *Carpococcyx* cuckoos from the Greater Sundas. *Forktail* 11: 135–150.

Cutter, P., Boontua, P. & Sri-Buarod, K. (2007) A recent record of Storm's Stork *Ciconia stormi* in Thailand. *Forktail* 23: 163–165.

Danielsen F., Kadarisman, R., Skov, H., Suwarman, U. & Verheugt W. J. M. (1997) The Storm's stork *Ciconia stormi* in Indonesia: breeding biology, population and conservation. *Ibis* 139: 67–75.

Dickinson, E. C., ed. (2003) *The Howard & Moore complete checklist of the birds of the world*. Third edition. London: Christopher Helm.

Dutson, G., Wilkinson, R. & Sheldon, B. (1991) Hook-billed Bulbul *Setornis criniger* and Grey-breasted Babbler *Malacopteron albogulare* at Barito Ulu, Kalimantan. *Forktail* 6: 79–82.

Edwards, D. P., Larsen, T. H., Docherty, T. D. S., Ansell, F. A., Hsu, W. W., Derhé, M. A., Hamer, K. C. & Wilcove, D. S. (2011) Degraded lands worth protecting: the biological importance of Southeast Asia's repeatedly logged forests. *Proc. Roy. Soc. B* 278(1702): 82–90.

Fredriksson, G. M. & Nijman, V. (2004) Habitat use and conservation status of two elusive ground birds (*Carpococcyx radiatus* and *Polyplectron schleiermacheri*) in the Sungai Wain Protection Forest, East Kalimantan, Indonesian Borneo. *Oryx* 38: 297–303.

Gaither, J. C., Jr. (1994) Understory avifauna of a Bornean peat swamp forest: is it depauperate? *Wilson Bull.* 106: 381–390.

Holmes, D. A. (1997) Kalimantan bird report 2. *Kukila* 9: 141–169.

Holmes, D. A. & Burton, K. (1987) Recent notes on the avifauna of Kalimantan. *Kukila* 3: 2–32.

Hornskov, J. (1987) More birds from Berbak Game Reserve, Sumatra. *Kukila* 3: 58.

IUCN (2010) *IUCN Red List of threatened species, version 2010.4*. <http://www.iucnredlist.org>. Downloaded on 22 March 2010.

Johns, A. G. (1996) Bird population persistence in Sabahan logging concessions. *Biol. Conserv.* 75: 3–10.

Laman, T. G., Gaither, J. C., & Lukas, D. E. (1996) Rain forest bird diversity in Gunung Palung National Park, West Kalimantan, Indonesia. *Trop. Biodiv.* 3: 281–296.

Laman, C. J., Gawin, D. F. A & Rahman, M. A. (2006) Quantifying the diversity of avifauna at Loagan Bunut National Park. Pp.163–172 in A. A. Tuen, A. K. Sayok, A. N. Toh & G. T. Noweg, eds. Scientific journey through Borneo. Loagan Bunut. Peat Swamp Forest Project, UNDP/GEF Funded (MAL/99/G31), Sarawak Forest Department, and Universiti Malaya Sarawak.

Lambert, F. R. (1992) The consequences of selective logging for Bornean lowland forest birds. *Phil. Trans. Roy. Soc. London B* 335: 443–457.

Long, A. J. & Collar, N. J. (2002) Distribution, status and natural history of the Bornean Ground Cuckoo *Carpococcyx radiatus*. *Forktail* 18: 101–119.

MacKinnon, J. & Phillipps, K. (2008) *A field guide to the birds of Borneo, Sumatra, Java and Bali*. New York: Oxford University Press.

MacKinnon, K., Hatta, G., Halim, H. & Mangalik, A. (1996) *The ecology of Kalimantan*. Singapore: Periplus Editions.

Mann, C. F. (2008) *The birds of Borneo: an annotated checklist*. Peterborough: British Ornithologists' Union (Checklist 23).

Miettinen, J. & Liew, S. (2010) Degradation and development of peatlands in Peninsular Malaysia and in the islands of Sumatra and Borneo since 1990. *Land Degrad. & Development* 21: 285–296.

Myers, S. (2009) *A field guide to the birds of Borneo*. Singapore: Talisman Publishing.

Nash, S. V. & Nash, A. D. (1988) An annotated checklist of the birds of Tanjung Puting National Park, Central Kalimantan. *Kukila* 3: 93–116.

O'Brien, T. G. & Kinnaird, M. (2008) A picture is worth a thousand words: the application of camera trapping to the study of birds. *Bird Conserv. Internatn.* 18: S144–162.

Page, S. E., Rieley, J. O., Doody, K., Hodgson, S., Husson, S., Jenkins, P., Morrogh-Bernard, H., Otway, S. & Wilshaw, S. (1997) Biodiversity of tropical peat swamp forest: a case study of animal diversity in the Sungei Sebangau catchment of Central Kalimantan, Indonesia. Pp 231–242 in J. O. Rieley & S. E. Page, eds. *Tropical peatlands*. Cardigan: Samara Publishing.

Page, S., Hoscilo, A., Langner, A., Tansey, K., Siegert, F., Limin, S. & Rieley, J. (2009) Tropical peatland fires in Southeast Asia. Pp.263–287 in M. A. Cochrane, ed. *Tropical fire ecology: climate change, land use and ecosystem dynamics*. UK: Springer/Praxis Publishing.

Posa, M. R. C. (2011) Peat swamp forest avifauna of Central Kalimantan, Indonesia: effects of habitat loss and degradation. *Biol. Conserv.* 144: 2548–2556.

Posa, M. R. C., Wijedasa, L. S. & Corlett, R. T. (2011) Biodiversity and conservation of tropical peat swamp forests. *BioScience* 61: 49–57.

Rahman, M. A. & Tuen, A. A. (2006) The avifauna. Pp.129–136 in F. Abang & I. Das, eds. *The biodiversity of a peat swamp forest in Sarawak*. Kota Samarahan: Universiti Malaya Sarawak.

Remsen, J. V. & Good, D. A. (1996) Misuse of data from mist-net captures to assess relative abundance in bird populations. *Auk* 113: 381–398.

Rieley, J. O., Ahmad-Shah, A. A. & Brady, M. A. (1996) The extent and nature of tropical peat swamps. Pp.17–53 in E. Maltby, C. P. Immirzi & R. J. Safford, eds. *Tropical peatlands of Southeast Asia*. Gland, Switzerland: International Union for Conservation of Nature.

van Schaik, C. P. & Brockman, D. (2005) Seasonality in primate ecology, reproduction, and life history: an overview. Pp.3–20 in D. K. Brockman & C. P. van Schaik, eds. *Seasonality in primates: studies of living and extinct human and non-human primates*. London: Cambridge University Press.

van Schaik, C. P., Wich, S. A., Utami, S. S. & Odom, K. (2005) A simple alternative to line transects of nests for estimating orangutan densities. *Primates* 46: 249–254.

Silvius, M. J. & Verheugt, W. J. M. (1986) The birds of Berbak Game Reserve, Jambi province, Sumatra. *Kukila* 2: 76–84.

Sheldon, F. H. (1987) Habitat preferences of the hook-billed bulbul *Setornis criniger* and the white-throated babbler *Malacopteron albogulare* in Borneo. *Forktail* 3: 17–25.

Sheldon, F. H., Moyle, R. G. & Kennard, J. (2001) *Ornithology of Sabah: history, gazetteer and annotated checklist, and bibliography*. Washington, D.C.: American Ornithologists' Union (*Orn. Monogr.* 52).

Sheldon, F. H., Moyle, R. G. & Marks, B. (2004) Report on a survey and collection of birds at Klias Forest Reserve, Sabah, Malaysia 5–12 February 2004. Unpublished.

Tuen, A. A. & Darub, A. W. (1999) The diversity and abundance of understorey birds in a peatswamp forest of Sarawak. *Malayan Nat. J.* 53: 287–294.

Vogel, E. R., Haag, L., Mitra-Setia, T., van Schaik, C. P. & Dominy, D. J. (2009) Foraging and ranging behavior during a fallback episode: *Hylobates albibaris* and *Pongo pygmaeus wurmbii* compared. *Amer. J. Phys. Anthr.* 140: 716–726.

Wartmann, F. (2008) Seasonality in spatio-temporal behaviour of female orangutans. MSc. thesis, University of Zurich, Switzerland.

Wilkinson, R., Dutson, G., Sheldon, B., Darjono & Noor, Y. R. (1991) The avifauna of the Barito Ulu region, Central Kalimantan. *Kukila* 5: 99–116.

Witt, C. C. & Sheldon, F. H. (1994) A review of the status and distribution of the Bornean bristlehead. *Kukila* 7: 54–67.

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Appendix

List of bird species recorded at Tuanan and surrounding areas and their occurrence in other sites containing peat swamp forest habitat

Abbreviations: VU – Vulnerable; EN – Endangered; NT – Near-threatened; LC – Least Concern; I – introduced to Borneo; M – migrant to Borneo; PSF – intact peat swamp forest; DIS – disturbed and non-forest habitat; RIV – riverine forest. Species marked with x* were recorded in 'swamp' (including peat swamp) habitat in other sites, x – habitat type not specified or recorded from non-swamp habitat, # – caught in mistnet.

Species		Status (IUCN 2010)	Tuanan record habitat (this study)	Tanjung Puting, Central Kalimantan (Bohap & Galdikas 1987; Nash & Nash 1988)	Gunung Palung, West Kalimantan (Laman *et al.* 1996)	Berbak, Sumatra (Silvius & Verheugt 1986, Hornskov 1987)	Loagan Bunut National Park, Sarawak (Gumal *et al.* 2008)	Unimas, Sarawak (mistnetting in regrowth, Tuen & Darub 1999, Rahman & Tuen 2006)
Black Partridge	*Melanaperdix niger*	VU	PSF	x	x*	x		
Crestless Fireback	*Laphura erythrapthalma*	VU	PSF	x	x		x*	
Storm's Stork	*Cicania starmi*	EN	PSF	x*	x*	x	x	
Lesser Adjutant	*Leptaptilas javanicus*	VU	DIS	x		x		
Black-thighed Falconet	*Micrahierax fringillarius*	LC	PSF, RIV, DIS	x*	x	x	x	
Black-winged Kite	*Elanus caeruleus*	LC	DIS			x	x	
Brahminy Kite	*Haliastur indus*	LC	DIS, RIV	x*		x	x	
Crested Serpent Eagle	*Spilarnis cheela*	LC	PSF, DIS, RIV	x*	x*	x	x*	
Crested goshawk	*Accipiter trivirgatus*	LC	PSF#	x*	x	x	x	x*
Changeable Hawk Eagle	*Spizaetus cirrhatus*	LC	PSF			x	x*	
Wallace's Hawk Eagle	*Spizaetus nanus*	VU	PSF		x	x	x*	
White-breasted Waterhen	*Amaurarnis phaenicurus*	LC	DIS	x	x		x	
Spotted Dove	*Streptapelia chinensis*	LC	DIS	x		x		
Cinnamon-headed Green Pigeon	*Treran fulvicallis*	NT	DIS	x*		x		
Pink-necked Green Pigeon	*Treran vernans*	LC	DIS, RIV	x*		x	x	
Thick-billed Green Pigeon	*Treran curvirastra*	LC	PSF	x*	x*	x		
Blue-crowned Hanging Parrot	*Lariculus galgulus*	LC	PSF, DIS, RIV	x*	x	x	x*	
Long-tailed Parakeet	*Psittacula langicauda*	NT	PSF, DIS, RIV	x*	x*	x	x*	
Indian Cuckoo	*Cuculus micrapterus*	LC	PSF	x*	x	x	x*	
Oriental Cuckoo	*Cuculus saturatus*	LC, M	PSF#					
Banded Bay Cuckoo	*Cacamantis sanneratii*	LC	PSF					x*
Plaintive Cuckoo	*Cacamantis merulinus*	LC	PSF, DIS	x*	x		x*	x*
Violet Cuckoo	*Chrysacaccyx xanthrahynchus*	LC	PSF, DIS	x*	x		x*	
Drongo Cuckoo	*Surniculus lugubris*	LC	PSF, DIS, RIV	x*	x	x		
Black-bellied Malkoha	*Phaenicaphaeus diardi*	NT	RIV		x*		x*	
Chestnut-bellied Malkoha	*Phaenicaphaeus sumatranus*	NT	PSF	x*		x	x*	
Raffles's Malkoha	*Phaenicaphaeus chlaraphaeus*	LC	PSF	x*	x*	x	x*	
Chestnut-breasted Malkoha	*Phaenicaphaeus curvirastris*	LC	PSF	x*	x*	x	x*	
Bornean Ground Cuckoo	*Carpacaccyx radiatus*	NT, E	PSF		x			
Greater Coucal	*Centrapus sinensis*	LC	PSF, DIS	x*	x*	x	x	
Lesser Coucal	*Centrapus bengalensis*	LC	DIS	x		x		
Brown Wood Owl	*Strix leptagrammica*	LC	PSF	x*	x*		x	
Savanna Nightjar	*Caprimulgus affinis*	LC	DIS					
Silver-rumped Needletail	*Rhaphidura leucapygialis*	LC	DIS, RIV	x*		x	x*	
Grey-rumped Treeswift	*Hemipracne langipennis*	LC	DIS, RIV	x*	x	x	x*	
Diard's Trogon	*Harpactes diardii*	NT	PSF, DIS	x*	x*	x*	x*	x*
Scarlet-rumped Trogon	*Harpactes duvaucelii*	NT	PSF	x*	x*	x	x*	x*
Dollarbird	*Eurystamus orientalis*	LC	PSF, RIV			x		
Stork-billed Kingfisher	*Halcyan capensis*	LC	DIS, RIV	x*	x	x	x*	x*

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Collared Kingfisher	*Tadiramphus chloris*	LC	DIS	x		x	x	
Oriental Dwarf Kingfisher	*Ceyx erithaca*	LC	PSF#	x*	x*	x	x*	x*
Blue-eared Kingfisher	*Alceda meninting*	LC	PSF, RIV	x*	x	x	x	x*
Blue-throated Bee-eater	*Meraps viridis*	LC	PSF, DIS, RIV	x*		x	x*	
Bushy-crested Hornbill	*Anarrhinus galeritus*	LC	PSF	x*	x*	x	x	
Oriental Pied Hornbill	*Anthracaceras albirastris*	LC	DIS, RIV	x*			x	
Black Hornbill	*Anthracaceras malayanus*	NT	PSF	x*	x*	x	x*	
Wrinkled Hornbill	*Aceras carrugatus*	NT	PSF	x*	x*	x	x	
Red-crowned Barbet	*Megalaima rafflesii*	NT	PSF, DIS, RIV	x*	x*	x	x*	x*
Red-throated Barbet	*Megalaima mystacaphanas*	NT	RIV	x	x*	x	x	
Blue-eared Barbet	*Megalaima australis*	LC	PSF, RIV	x*	x*	x	x*	
Brown Barbet	*Calaramphus fuliginasus*	LC	PSF	x*	x*	x	x*	
Rufous Piculet	*Sasia abnarmis*	LC	PSF#	x*	x*		x*	x*
Sunda Pygmy Woodpecker	*Dendracapas maluccensis*	LC	PSF, DIS	x		x		
Rufous Woodpecker	*Celeus brachyurus*	LC	PSF	x*	x		x*	x*
White-bellied Woodpecker	*Dryacapus javensis*	LC	DIS, RIV	x*	x	x	x*	
Banded Woodpecker	*Picus mineaceus*	LC	PSF, RIV	x	x	x		x*
Crimson-winged Woodpecker	*Picus puniceus*	LC	RIV	x*	x*		x*	x*
Maroon Woodpecker	*Blythipicus rubiginasus*	LC	PSF	x	x*	x	x*	x*
Orange-backed Woodpecker	*Reinwardtipicus validus*	LC	PSF, DIS	x*	x*		x	
Buff-rumped Woodpecker	*Meiglyptes tristis*	LC	PSF, DIS	x*	x		x*	
Buff-necked Woodpecker	*Meiglyptes tukki*	NT	PSF	x*	x*	x	x*	x*
Grey-and-buff Woodpecker	*Hemicircus cancretus*	LC	PSF, DIS, RIV	x*	x*	x		
Great Slaty Woodpecker	*Mulleripicus pulverulentus*	VU	PSF	x*	x*		x	
Green Broadbill	*Calyptamena viridis*	NT	PSF	x*	x*		x	
Black-and-red Broadbill	*Cymbirhynchus macrarhynchas*	LC	RIV	x*	x	x	x	x*
Banded Broadbill	*Eurylaimus javanicus*	LC	PSF	x*	x	x		
Black-and-yellow Broadbill	*Eurylaimus achramalus*	NT	PSF	x*	x	x	x*	
Dusky Broadbill	*Carydan sumatranus*	LC	PSF		x*	x	x*	
Golden-bellied Gerygone	*Gerygane sulphurea*	LC	RIV	x*				
Large Woodshrike	*Tephradarnis virgatus*	LC	RIV	x	x		x*	
White-breasted Woodswallow	*Artamus leucarynchus*	LC	DIS, RIV	x		x		
Common Iora	*Aegithina tiphia*	LC	PSF, RIV	x*	x	x	x	x*
Green Iora	*Aegithina viridissima*	NT	PSF	x*	x		x*	x*
Bornean Bristlehead	*Pityriasis gymnacephala*	NT, E	PSF	x*	x		x*	
Lesser Cuckooshrike	*Caracina fimbriata*	LC	PSF, RIV	x*	x		x*	
Pied Triller	*Lalage nigra*	LC	DIS	x				
Fiery Minivet	*Pericracatus igneus*	NT	PSF, DIS, RIV	x*	x*	x	x*	
Scarlet Minivet	*Pericracatus flammeus*	LC	PSF	x*	x	x	x*	
Black-winged Flycatcher-shrike	*Hemipus hirundinaceus*	LC	PSF, DIS, RIV	x*	x	x	x*	x*
Mangrove Whistler	*Pachycephala cinerea*	LC	PSF#	x*		x		
Long-tailed Shrike	*Lanius schach*	LC	DIS, RIV	x				
Tiger Shrike	*Lanius tigrinus*	LC, M	DIS				x	
Dark-throated Oriole	*Orialus xanthanatus*	NT	PSF, DIS	x*	x*		x*	

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Bronzed Drongo	*Dicrurus oeneus*	LC	RIV	x*	x	x	x*	x*
Pied Fantail	*Rhipiduro jovonico*	LC	PSF, DIS, RIV	x		x	x,	x*
Black-naped Monarch	*Hypothymis ozureo*	LC	PSF#	x*	x*	x	x*	
Asian Paradise-flycatcher	*Terpsiphone porodisi*	LC	PSF#	x*	x*	x	x*	
Pacific Swallow	*Hirundo tohitico*	LC	DIS, RIV	x*		x	x	x*
Barn Swallow	*Hirundo rustico*	LC, M	PSF				x*	
Yellow-bellied Prinia	*Prinio floviventris*	LC	DIS	x		x	x	x*
Dark-necked Tailorbird	*Orthotomus otroguloris*	LC	PSF, RIV	x*	x	x*	x*	
Rufous-tailed Tailorbird	*Orthotomus sericeus*	LC	PSF#, DIS	x*	x		x,	x*
Ashy Tailorbird	*Orthotomus ruficeps*	LC	PSF#, DIS	x*		x	x*	x*
Arctic Warbler	*Phylloscopus boreolis*	LC, M	PSF					
Sooty-headed Bulbul	*Pycnonotus ourigoster*	LC, I	RIV					
Puff-backed Bulbul	*Pycnonotus eutilotus*	NT	DIS	x*	x*	x	x*	x*
Yellow-vented Bulbul	*Pycnonotus goiovier*	LC	PSF, DIS	x*		x		x*
Olive-winged Bulbul	*Pycnonotus plumosus*	LC	DIS, RIV	x*		x	x*	x*
Cream-vented Bulbul	*Pycnonotus simplex*	LC	PSF#	x*	x*	x	x*	
Spectacled Bulbul	*Pycnonotus erythroptholmos*	LC	PSF	x*	x*	x	x*	x*
Hook-billed Bulbul	*Setornis criniger*	VU	PSF#	x*	x*	x*	x*	
Black-capped Babbler	*Pellorneum copistrotum*	LC	PSF#, DIS	x*	x*	x	x*	x*
White-chested Babbler	*Trichostomo rostrotum*	NT	PSF#, DIS	x*		x	x*	x*
Short-tailed Babbler	*Molococinclo moloccensis*	NT	PSF#	x*	x*		x*	x*
Scaly-crowned Babbler	*Molocopteron cinereum*	LC	PSF#	x*	x*		x*	
Rufous-crowned Babbler	*Molocopteron mognum*	NT	PSF#	x*		x	x*	
Grey-breasted Babbler	*Molocopteron olbogulore*	NT	PSF#	x*	x*		x*	x*
Chestnut-rumped Babbler	*Stochyris moculoto*	NT	PSF#, DIS	x*	x*	x	x*	
Black-throated Babbler	*Stochyris nigricollis*	NT	PSF#	x*	x*		x*	x*
Chestnut-winged Babbler	*Stochyris erythroptero*	LC	PSF#	x*	x*		x*	x*
Striped Tit Babbler	*Mocronous guloris*	LC	PSF, DIS	x*	x		x,	x*
Fluffy-backed Tit Babbler	*Mocronous ptilosus*	NT	PSF#	x*	x	x	x*	x*
Asian Fairy Bluebird	*Ireno puello*	LC	PSF, RIV	x*	x*	x	x*	x*
Velvet-fronted Nuthatch	*Sitto frontolis*	LC	PSF	x*	x	x		
Common Hill Myna	*Groculo religioso*	LC	PSF, DIS	x*	x*	x	x*	
Oriental Magpie Robin	*Copsychus souloris*	LC	DIS	x*	x*	x	x	x*
White-rumped Shama	*Copsychus moloboricus*	LC	PSF#, DIS	x*	x*	x*	x*	x*
Rufous-tailed Shama	*Trichixos pyrropygus*	NT	PSF#	x*	x*	x*	x*	
Grey-chested Jungle Flycatcher	*Rhinomyios umbrotilis*	NT	PSF#	x*	x*	x*	x*	x*
Malaysian Blue-flycatcher	*Cyornis turcosus*	NT	RIV	x*	x	x		
Greater Green Leafbird	*Chloropsis sonneroti*	LC	PSF	x*	x*	x	x*	
Lesser Green Leafbird	*Chloropsis cyonopogon*	NT	PSF, DIS	x*	x*	x	x*	
Yellow-breasted Flowerpecker	*Prionochilus moculotus*	LC	PSF#	x*	x*	x	x*	x*
Crimson-breasted Flowerpecker	*Prionochilus percussus*	LC	PSF#, DIS	x	x*	x		
Scarlet-breasted Flowerpecker	*Prionochilus thorocicus*	NT	PSF	x*	x*		x*	
Orange-bellied Flowerpecker	*Dicoeum trigonostigmo*	LC	PSF, DIS	x*	x*	x	x*	x*
Scarlet-backed Flowerpecker	*Dicoeum cruentotum*	LC	PSF	x			x*	

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Ruby-cheeked Sunbird	*Anthreptes singalensis*	LC	PSF, DIS	x*	x*	x		x*
Plain Sunbird	*Anthreptes simplex*	LC	PSF	x*			x*	x*
Brown-throated Sunbird	*Anthreptes malacensis*	LC	PSF, DIS	x*		x	x*	x*
Purple-naped Sunbird	*Hypagramma hypagrammicum*	LC	PSF[#]	x*	x*	x	x*	x*
Purple-throated Sunbird	*Nectarinia sperata*	LC	PSF	x*	x*	x	x*	
Olive-backed Sunbird	*Nectarinia jugularis*	LC	DIS	x		x	x	x*
Crimson Sunbird	*Aethapyga siparaja*	LC	PSF, RIV	x*		x	x	x*
Little Spiderhunter	*Arachnathera langirastra*	LC	PSF[#], DIS	x*	x*	x	x*	x*
Yellow-eared Spiderhunter	*Arachnathera chrysogenys*	LC	PSF	x*	x*	x		
Eurasian Tree Sparrow	*Passer mantanus*	LC, I	DIS					
Dusky Munia	*Lanchura fuscans*	LC, E	DIS	x*	x		x	x*